NATIONAL ADVISORY COMMITTEE FOR AERONAUTICS

TECHNICAL NOTE

No. 1737

EFFECT OF VARIATION IN DIAMETER AND PITCH OF RIVETS ON COMPRESSIVE STRENGTH OF PANELS WITH Z-SECTION STIFFENERS

PANELS THAT FAIL BY LOCAL BUCKLING AND HAVE VARIOUS VALUES OF WIDTH-TO-THICKNESS RATIO FOR THE WEBS OF THE STIFFENERS

By Norris F. Dow and William A. Hickman

Langley Aeronautical Laboratory
Langley Field, Va.

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SUMMARY

An experimental investigation is being conducted to determine the effect of varying the rivet diameter and pitch on the compressive strength of flat 24S-T aluminum-alloy Z-stiffened panels of the type for which design charts are available. The present part of the investigation is concerned with panels which have various values of width-to-thickness ratio of the webs of the stiffeners and have such length that failure is by local buckling. The results show that for these panels, regardless of their stiffener widths, the compressive strengths increased appreciably with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

INTRODUCTION

The design and analysis of sheet-stiffener panels for aircraft structures have been the subject of extensive experimental and theoretical investigations, but the determination of the size and pitch of rivets for attaching sheet to stiffener is a problem that has not been adequately solved. In reference 1 charts and procedures are presented for the design of Z-stiffened panels to carry a given intensity of loading at a given panel length. The test data on which these design charts were based, however, were obtained for an arbitrary diameter and pitch of the rivets. An investigation is therefore being conducted in the Langley structures research laboratory of the National Advisory Committee for Aeronautics to determine the effect of a variation in the rivet diameter and pitch on the strength of 24S-T aluminum-alloy panels with longitudinal Z-section stiffeners of the type for which the design charts of reference 1 were prepared.

Four basic variables have been considered in this investigation of the effect of riveting on panel strengths:

(1) The ratio of stiffener thickness to skin thickness t_W/t_S

(2) The slenderness ratio L/ρ

(3) The ratio of stiffener spacing to skin thickness b_S/t_S

(4) The ratio of stiffener width to stiffener thickness b_W/t_W

The range of values tested for each variable is given in table 1, which also includes the references in which the data are presented.

The results of varying the ratio of stiffener width to stiffener thickness b_W/t_W are given in the present paper.

SYMBOLS

L	length of specimen, inches
ρ	radius of gyration, inches
L/ρ	slenderness ratio
W	width of specimen, inches
b_S	spacing of stiffeners on sheet, inches
b_A	width of attachment flange of stiffeners, inches
b_W	width of web of stiffeners, inches
b_F	width of outstanding flange of stiffeners, inches
t_S	thickness of sheet, inches
t_W	thickness of web of stiffener, inches
d	diameter of rivets, inches
p	pitch of rivets, inches
h	depth of countersink for rivets, inches
σ_{cy}	compressive yield stress for material, ksi
$\bar{\sigma}_f$	average compressive stress at failing load, ksi
c	coefficient of end fixity in Euler column formula

P_i compressive load per inch of panel width, kips per inch

R radius of bend

TEST SPECIMENS AND METHOD OF TESTING

For all parts of the investigation.- The specimens consisted of 24S-T aluminum-alloy panels having longitudinal Z-section stiffeners as shown in figure 1. The stiffeners were riveted to the sheet with A17S-T flat-head rivets (AN442AD). In all cases the minimum rivet pitch used was equal to three times the rivet diameter. The rivets were driven by the NACA flush-riveting process in which the rivet is inserted with the head opposite the countersunk end of the hole, the shank of the rivet is driven into the cavity formed by the countersink, and the excess material is removed with a milling tool. A countersink angle of 60° was used.

Ultimate compressive loads for the specimens were determined in a hydraulic testing machine having an accuracy of one-half of 1 percent of the load. The ends of the specimens were ground accurately flat and parallel in a special grinder, and the method of alinement in the testing machine was such as to insure a uniform bearing over the ends of the specimens.

For the present part of the investigation.- Five width-to-thickness ratios for the stiffeners, corresponding to values of b_W/t_W of 20, 25, 30, 40, and 50, were investigated. (See fig. 2.) Two thicknesses of sheet were used to give two ratios of stiffener thickness to sheet thickness $\left(\frac{t_W}{t_S} = 1.00 \text{ and } 0.63\right)$. The lengths of the panels were so chosen $\left(\frac{L}{\rho} = 20\right)$ that no column bending failures occurred. The proportions $\frac{b_S}{t_S} = 25$, $\frac{b_A}{t_W} = 9.5$, and $\frac{b_F}{b_W} = 0.4$ were the same for all panels.

The with-grain compressive yield strength σ_{cy} of the material before forming was found to be as follows: 47.2 ksi (max.), 45.2 ksi (av.), and 44.0 ksi (min.).

RESULTS AND DISCUSSION

The results are presented in figure 3 and table 2. In figure 3, $\bar{\sigma}_f$, calculated simply as the failing load divided by the cross-sectional area of the panel, is plotted against the ratio of the rivet diameter to the sum of the thicknesses of sheet and stiffener $\frac{d}{t_S + t_W}$ in order to present the results in a manner similar to that used in references 2, 3, and 4. Figure 3 shows that for all values of t_W/t_S and b_W/t_W investigated the compressive strengths increased with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

These results differ from those of reference 5 in which the compressive strength of Z-stiffened shells was found to change very little with rivet spacing when failure occurred by local buckling of the stiffeners. The panel tests described in reference 5, however, covered an entirely different range of proportions from that of the present investigation. In reference 5 the proportions covered were such $\left(\frac{t_W}{t_S} = 2 \text{ or } 3, \frac{b_S}{t_S} = 350\right)$ that the sheet contributed only a small amount to the load-carrying ability of the assembly. Changing the rivet pitch over the range investigated therein $\left(\frac{p}{t_S + t_W} = 14 \text{ to } 50\right)$, or even increasing it to considerably larger values of $\frac{p}{t_S + t_W}$ so that the sheet contributed a negligible load-carrying capacity, would be expected to produce only small changes in panel strength.

CONCLUDING REMARKS

Results are presented of an investigation to determine the effect of varying the rivet diameter and pitch on the compressive strength of flat 24S-T aluminum-alloy Z-stiffened panels of the type for which design charts are available. The present part of the investigation is concerned with panels which have various values of width-to-thickness ratio of the webs of the stiffeners and have such length that failure is by local buckling. The results show that for these panels, regardless of their width-to-thickness ratio, the compressive strengths increased appreciably with either an increase in the diameter of the rivets or a decrease in the pitch of the rivets.

Langley Aeronautical Laboratory
National Advisory Committee for Aeronautics
Langley Field, Va., September 11, 1948

REFERENCES

1. Schuette, Evan H.: Charts for the Minimum-Weight Design of 24S-T Aluminum-Alloy Flat Compression Panels with Longitudinal Z-Section Stiffeners. NACA Rep. No. 827, 1945.

2. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. I - Panels with Close Stiffener Spacing That Fail by Local Buckling. NACA RB No. L5G03, 1945.

3. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. Panels of Various Lengths with Close Stiffener Spacing. NACA TN No. 1421, 1947.

4. Dow, Norris F., and Hickman, William A.: Effect of Variation in Diameter and Pitch of Rivets on Compressive Strength of Panels with Z-Section Stiffeners. Panels of Various Stiffener Spacings That Fail by Local Buckling. NACA TN No. 1467, 1947.

5. Kromm, A.: Einfluss der Nietteilung auf die Druckfestigkeit versteifter Schalen aus Duralumin. Luftfahrtforschung, Bd. 14, Lfg. 3, March 20, 1937, pp. 116-120.

TABLE 1.- RANGE OF VALUES TESTED FOR EACH VARIABLE IN THE INVESTIGATION OF THE EFFECT OF RIVETING ON PANEL STRENGTH

$\frac{t_W}{t_S}$	$\frac{L}{\rho}$	$\frac{b_S}{t_S}$	$\frac{b_W}{t_W}$	Reference
0.51 .63 .79 1.00 1.25	20	25	20	2
0.63 1.00	20 40 70 120	25	20	3
0.63 1.00	20	25 30 35 40 50 60 75	20	4
0.63 1.00	20	25	20 25 30 40 50	Present paper

TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS SHOWING EFFECTS OF VARYING RIVET PITCH AND RIVET DIAMETER

Diam. of rivets, d (in.)	Depth of countersink, h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{\delta}}$ (ksi)
$t_S = 0.064$ in.; $b_S = 1.60$ in.; $L = 10.40$ in.; $W = 8.64$ in.; $b_W = 1.28$ in.; $b_F = 0.51$ in. $\frac{t_W}{t_S} = 1.00$; $\frac{b_S}{t_S} = 25$[a]; $\frac{b_W}{t_W} = 20$				
1/16	0.035	3/16	43.050	1.233
		3/8	41.450	1.180
		5/8	[b]36.855	1.013
		15/16	[b]38.380	1.093
		$1\frac{5}{16}$	29.300	.840
		$1\frac{3}{4}$	26.700	.768
3/32	.040	9/32	44.800	1.303
		3/8	43.500	1.245
		5/8	[b]38.070	1.069
		15/16	[b]40.035	1.140
		$1\frac{5}{16}$	33.400	.950
		$1\frac{3}{4}$	30.700	.891
1/8	.050	3/8	44.600	1.317
		5/8	[b]43.735	1.227
		15/16	[b]41.710	1.186
		$1\frac{5}{16}$	34.750	.990
		$1\frac{3}{4}$	32.200	.856
5/32	.060	15/32	45.000	1.318
		5/8	43.870	1.197
		15/16	40.500	1.142
		$1\frac{5}{16}$	36.100	1.032
		$1\frac{3}{4}$	[b]33.800	.973
3/16	.065	9/16	45.340	1.329
		5/8	44.700	1.232
		15/16	40.850	1.160
		$1\frac{5}{16}$	37.600	1.077
		$1\frac{3}{4}$	[b]33.800	.968
1/4	.065	3/4	44.485	1.272
		15/16	44.485	1.290
		$1\frac{5}{16}$	38.900	1.104
		$1\frac{3}{4}$	35.350	1.022

[a]Data for $\frac{b_S}{t_S} = 25$ is from reference 2.

[b]Average of two tests.

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink, h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{\delta}}$ (ksi)
t_S = 0.064 in.; b_S = 1.60 in.; L = 12.80 in.; W = 8.64 in.; b_W = 1.60 in.; b_F = 0.64 in.; $\frac{t_W}{t_S}$ = 1.00; $\frac{b_S}{t_S}$ = 25; $\frac{b_W}{t_W}$ = 25				
1/16	0.035	3/16	43.300	1.051
		3/8	41.500	1.010
		5/8	38.670	.945
		15/16	37.880	.920
		$1\frac{5}{16}$	32.790	.801
		$1\frac{3}{4}$	26.850	.665
3/32	.040	9/32	43.290	1.054
		3/8	42.070	1.031
		5/8	41.760	1.020
		15/16	39.340	.958
		$1\frac{5}{16}$	34.580	.844
		$1\frac{3}{4}$	30.200	.751
1/8	.050	3/8	42.720	1.042
		5/8	42.640	1.042
		15/16	39.140	.953
		$1\frac{5}{16}$	35.970	.876
		$1\frac{3}{4}$	31.920	.795
5/32	.060	15/32	43.610	1.060
		5/8	43.450	1.053
		15/16	40.220	.977
		$1\frac{5}{16}$	36.420	.882
		$1\frac{3}{4}$	33.760	.825
3/16	.065	9/16	41.910	1.023
		5/8	42.980	1.048
		15/16	40.950	.996
		$1\frac{5}{16}$	36.510	.878
		$1\frac{3}{4}$	33.480	.814
1/4	.065	3/4	41.230	1.002
		15/16	40.210	.975
		$1\frac{5}{16}$	37.540	.906
		$1\frac{3}{4}$	33.310	.810

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink, h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
t_S = 0.064 in.; b_S = 1.60 in.; L = 15.66 in.; W = 8.64 in.; b_W = 1.92 in.; b_F = 0.77 in.; $\frac{t_W}{t_S} = 1.00$; $\frac{b_S}{t_S} = 25$; $\frac{b_W}{t_W} = 30$				
1/16	0.035	3/16	39.790	0.896
		3/8	38.810	.875
		5/8	37.450	.842
		15/16	35.390	.791
		$1\frac{5}{16}$	31.830	.710
		$1\frac{3}{4}$	25.360	.568
3/32	.040	9/32	39.040	.880
		3/8	39.250	.890
		5/8	38.580	.872
		15/16	37.470	.841
		$1\frac{5}{16}$	34.640	.777
		$1\frac{3}{4}$	29.290	.658
1/8	.050	3/8	39.700	.901
		5/8	38.970	.878
		15/16	37.990	.849
		$1\frac{5}{16}$	34.940	.783
		$1\frac{3}{4}$	30.180	.676
5/32	.060	15/32	39.320	.887
		5/8	39.190	.887
		15/16	37.850	.847
		$1\frac{5}{16}$	36.730	.827
		$1\frac{3}{4}$	31.420	.701
3/16	.065	9/16	39.390	.865
		5/8	39.250	.888
		15/16	38.020	.854
		$1\frac{5}{16}$	37.110	.838
		$1\frac{3}{4}$	32.380	.729
1/4	.065	3/4	37.950	.856
		15/16	37.530	.843
		$1\frac{5}{16}$	36.830	.830
		$1\frac{3}{4}$	33.140	.746

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L/\sqrt{c}}$ (ksi)
$t_S = 0.064$ in.; $b_S = 1.60$ in.; $L = 20.88$ in.; $W = 8.64$ in.; $b_W = 2.56$ in.; $b_F = 1.02$ in.; $\frac{t_W}{t_S} = 1.00$; $\frac{b_S}{t_S} = 25$; $\frac{b_W}{t_W} = 40$				
1/16	0.035	3/16	30.940	0.609
		3/8	29.930	.589
		5/8	28.830	.567
		15/16	26.530	.518
		$1\frac{5}{16}$	25.170	.496
		$1\frac{3}{4}$	23.640	.477
3/32	.040	9/32	31.040	.638
		3/8	31.110	.623
		5/8	30.370	.598
		15/16	28.180	.554
		$1\frac{5}{16}$	26.870	.530
		$1\frac{3}{4}$	25.060	.502
1/8	.050	3/8	31.900	.636
		5/8	30.490	.602
		15/16	29.040	.568
		$1\frac{5}{16}$	27.100	.543
		$1\frac{3}{4}$	25.900	.524
5/32	.060	15/32	31.780	.638
		5/8	31.880	.624
		15/16	29.780	.596
		$1\frac{5}{16}$	29.300	.579
		$1\frac{3}{4}$	26.470	.529
3/16	.065	9/16	31.990	.628
		5/8	31.150	.613
		15/16	30.770	.607
		$1\frac{5}{16}$	28.840	.568
		$1\frac{3}{4}$	26.170	.514
1/4	.065	3/4	31.880	.642
		15/16	30.490	.598
		$1\frac{5}{16}$	29.220	.576
		$1\frac{3}{4}$	27.110	.530

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L/\sqrt{c}}$ (ksi)
$t_S = 0.064$ in.; $b_S = 1.60$ in.; L = 26.04 in.; W = 8.64 in.; $b_W = 3.20$ in.; $b_F = 1.28$ in.; $\frac{t_W}{t_S} = 1.00$; $\frac{b_S}{t_S} = 25$; $\frac{b_W}{t_W} = 50$				
1/16	0.035	3/16	27.660	0.520
		3/8	26.860	.503
		5/8	25.390	.474
		15/16	23.160	.434
		$1\frac{5}{16}$	22.320	.421
		$1\frac{3}{4}$	19.510	.368
3/32	.040	9/32	27.980	.536
		3/8	27.560	.525
		5/8	27.130	.510
		15/16	25.190	.472
		$1\frac{5}{16}$	23.740	.446
		$1\frac{3}{4}$	21.030	.396
1/8	.050	3/8	27.720	.521
		5/8	27.480	.516
		15/16	26.530	.503
		$1\frac{5}{16}$	25.200	.475
		$1\frac{3}{4}$	21.690	.409
5/32	.060	15/32	28.230	.542
		5/8	28.400	.544
		15/16	27.380	.515
		$1\frac{5}{16}$	25.780	.485
		$1\frac{3}{4}$	23.000	.435
3/16	.065	9/16	28.060	.527
		5/8	27.540	.517
		15/16	26.830	.502
		$1\frac{5}{16}$	25.560	.480
		$1\frac{3}{4}$	23.240	.437
1/4	.065	3/4	28.010	.528
		15/16	27.310	.508
		$1\frac{5}{16}$	26.440	.496
		$1\frac{3}{4}$	24.340	.460

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L/\sqrt{c}}$ (ksi)
t_S = 0.102 in.; b_S = 2.55 in.; L = 9.44 in.; W = 13.39 in.; b_W = 1.28 in.; b_F = 0.51 in. $\frac{t_W}{t_S} = 0.63$; $\frac{b_S}{t_S}$ = 25[a]; $\frac{b_W}{t_W} = 20$				
3/32	0.050	9/32	42.300	1.412
		9/16	39.300	1.288
		7/8	38.170	1.218
		$1\frac{7}{32}$	35.400	1.158
		$1\frac{19}{32}$	34.500	1.129
		2	30.000	.984
1/8	.060	3/8	43.800	1.445
		9/16	40.400	1.321
		7/8	39.700	1.263
		$1\frac{7}{32}$	37.800	1.237
		$1\frac{19}{32}$	35.500	1.167
		2	30.240	.984
5/32	.070	15/32	[b]43.590	1.431
		9/16	[b]42.335	1.388
		7/8	41.050	1.310
		$1\frac{7}{32}$	37.850	1.236
		$1\frac{19}{32}$	35.750	1.168
		2	31.800	1.049
3/16	.080	9/16	[b]45.150	1.451
		7/8	[c]41.150	1.327
		$1\frac{7}{32}$	38.800	1.263
		$1\frac{19}{32}$	38.150	1.253
		2	31.900	1.042
1/4	.090	3/4	44.050	1.471
		7/8	[b]43.000	1.378
		$1\frac{7}{32}$	40.700	1.329
		$1\frac{19}{32}$	39.800	1.307
		2	34.100	1.120

[a]Data for $\frac{b_S}{t_S}$ = 25 is from reference 2.

[b]Average of two tests.

[c]Average of three tests.

TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L/\sqrt{\delta}}$ (ksi)
t_S = 0.102 in.; b_S = 2.55 in.; L = 11.64 in.; W = 13.39 in.; b_W = 1.60 in.; b_F = 0.64 in.; $\frac{t_W}{t_S}$ = 0.63; $\frac{b_S}{t_S}$ = 25; $\frac{b_W}{t_W}$ = 25				
3/32	0.050	9/32	42.800	1.106
		9/16	40.580	1.049
		7/8	39.100	.990
		$1\frac{7}{32}$	36.210	.938
		$1\frac{19}{32}$	35.480	.925
		2	29.890	.754
1/8	.060	3/8	42.650	1.102
		9/16	41.910	1.078
		7/8	40.190	1.034
		$1\frac{7}{32}$	39.060	1.005
		$1\frac{19}{32}$	36.500	.947
		2	34.150	.891
5/32	.070	15/32	43.580	1.128
		9/16	43.120	1.118
		7/8	40.550	1.033
		$1\frac{7}{32}$	40.510	1.051
		$1\frac{19}{32}$	37.470	.987
		2	33.800	.874
3/16	.080	9/16	42.170	1.089
		7/8	40.340	1.041
		$1\frac{7}{32}$	39.780	1.030
		$1\frac{19}{32}$	37.390	.958
		2	33.850	.872
1/4	.090	3/4	42.960	1.123
		7/8	41.890	1.080
		$1\frac{7}{32}$	40.560	1.049
		$1\frac{19}{32}$	37.420	.967
		2	34.380	.899

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L'/\sqrt{c}}$ (ksi)
t_S = 0.102 in.; b_S = 2.55 in.; L = 14.52 in.; W = 13.39 in.; b_W = 1.92 in.; b_F = 0.77 in.; $\frac{t_W}{t_S}$ = 0.63; $\frac{b_S}{t_S}$ = 25; $\frac{b_W}{t_W}$ = 30				
3/32	0.050	9/32	39.410	0.900
		9/16	37.690	.841
		7/8	36.090	.800
		$1\frac{7}{32}$	35.060	.778
		$1\frac{19}{32}$	32.850	.733
		2	30.400	.672
1/8	.060	3/8	39.800	.887
		9/16	38.960	.874
		7/8	37.780	.845
		$1\frac{7}{32}$	36.000	.805
		$1\frac{19}{32}$	33.960	.754
		2	33.460	.742
5/32	.070	15/32	39.970	.888
		9/16	39.110	.868
		7/8	37.850	.836
		$1\frac{7}{32}$	37.860	.845
		$1\frac{19}{32}$	35.990	.803
		2	33.290	.753
3/16	.080	9/16	38.210	.838
		7/8	37.910	.841
		$1\frac{7}{32}$	37.070	.829
		$1\frac{19}{32}$	36.080	.803
		2	33.290	.741
1/4	.090	3/4	39.840	.883
		7/8	39.400	.871
		$1\frac{7}{32}$	38.220	.845
		$1\frac{19}{32}$	36.570	.814
		2	33.930	.754

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TABLE 2. - NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Continued

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_i}{L/\sqrt{c}}$ (ksi)
t_S = 0.102 in.; b_S = 2.55 in.; L = 20.00 in.; W = 13.39 in.; b_W = 2.56 in.; b_F = 1.02 in.; $\frac{t_W}{t_S}$ = 0.63; $\frac{b_S}{t_S}$ = 25; $\frac{b_W}{t_W}$ = 40				
3/32	0.050	9/32	32.850	0.601
		9/16	30.840	.565
		7/8	28.810	.524
		$1\frac{7}{32}$	28.010	.508
		$1\frac{19}{32}$	26.500	.487
		2	25.700	.474
1/8	.060	3/8	32.910	.602
		9/16	32.850	.597
		7/8	30.500	.558
		$1\frac{7}{32}$	29.580	.543
		$1\frac{19}{32}$	27.960	.507
		2	26.610	.486
5/32	.070	15/32	32.820	.598
		9/16	32.750	.593
		7/8	31.610	.577
		$1\frac{7}{32}$	30.560	.560
		$1\frac{19}{32}$	29.110	.533
		2	28.080	.517
3/16	.080	9/16	33.440	.616
		7/8	32.140	.588
		$1\frac{7}{32}$	30.920	.564
		$1\frac{19}{32}$	29.510	.535
		2	27.930	.507
1/4	.090	3/4	33.110	.602
		7/8	33.380	.614
		$1\frac{7}{32}$	32.110	.586
		$1\frac{19}{32}$	31.130	.573
		2	30.270	.556

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TABLE 2.- NOMINAL DIMENSIONS OF Z-STIFFENED PANELS AND TEST RESULTS - Concluded

Diam. of rivets, d (in.)	Depth of countersink h (in.)	Pitch of rivets, p (in.)	Average stress at failing load, $\bar{\sigma}_f$ (ksi)	$\frac{P_1}{L/\sqrt{c}}$ (ksi)
$t_S = 0.102$ in.; $b_S = 2.55$ in.; $L = 25.70$ in.; $W = 13.39$ in.; $b_W = 3.20$ in.; $b_F = 1.28$ in.; $\frac{t_W}{t_S} = 0.63$; $\frac{b_S}{t_S} = 25$; $\frac{b_W}{t_W} = 50$				
3/32	0.050	9/32	29.500	0.474
		9/16	27.880	.444
		7/8	25.590	.405
		$1\frac{7}{32}$	23.540	.327
		$1\frac{19}{32}$	22.290	.354
		2	21.670	.343
1/8	.060	3/8	30.170	.481
		9/16	29.190	.465
		7/8	27.220	.432
		$1\frac{7}{32}$	26.750	.425
		$1\frac{19}{32}$	24.000	.378
		2	23.450	.378
5/32	.070	15/32	30.170	.479
		9/16	29.820	.474
		7/8	29.000	.462
		$1\frac{7}{32}$	27.110	.433
		$1\frac{19}{32}$	25.670	.409
		2	24.600	.394
3/16	.080	9/16	29.350	.466
		7/8	28.880	.458
		$1\frac{7}{32}$	27.650	.441
		$1\frac{19}{32}$	26.070	.415
		2	24.650	.393
1/4	.090	3/4	31.380	.502
		7/8	29.520	.462
		$1\frac{7}{32}$	29.230	.468
		$1\frac{19}{32}$	27.450	.434
		2	26.640	.427

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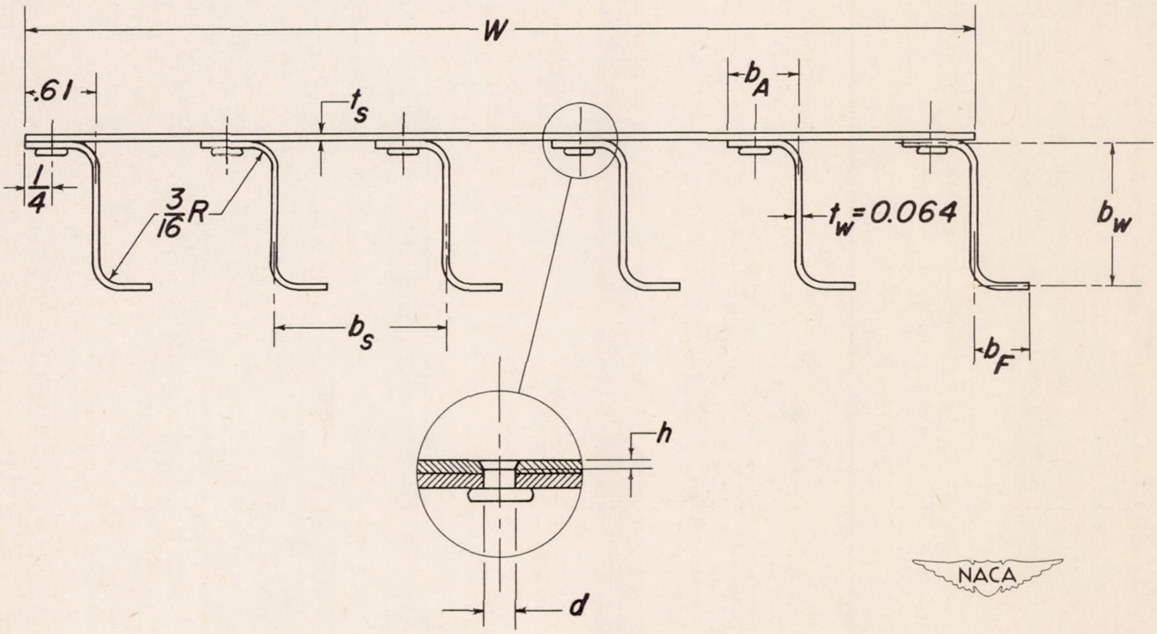


Figure 1.— Cross section of test specimens.

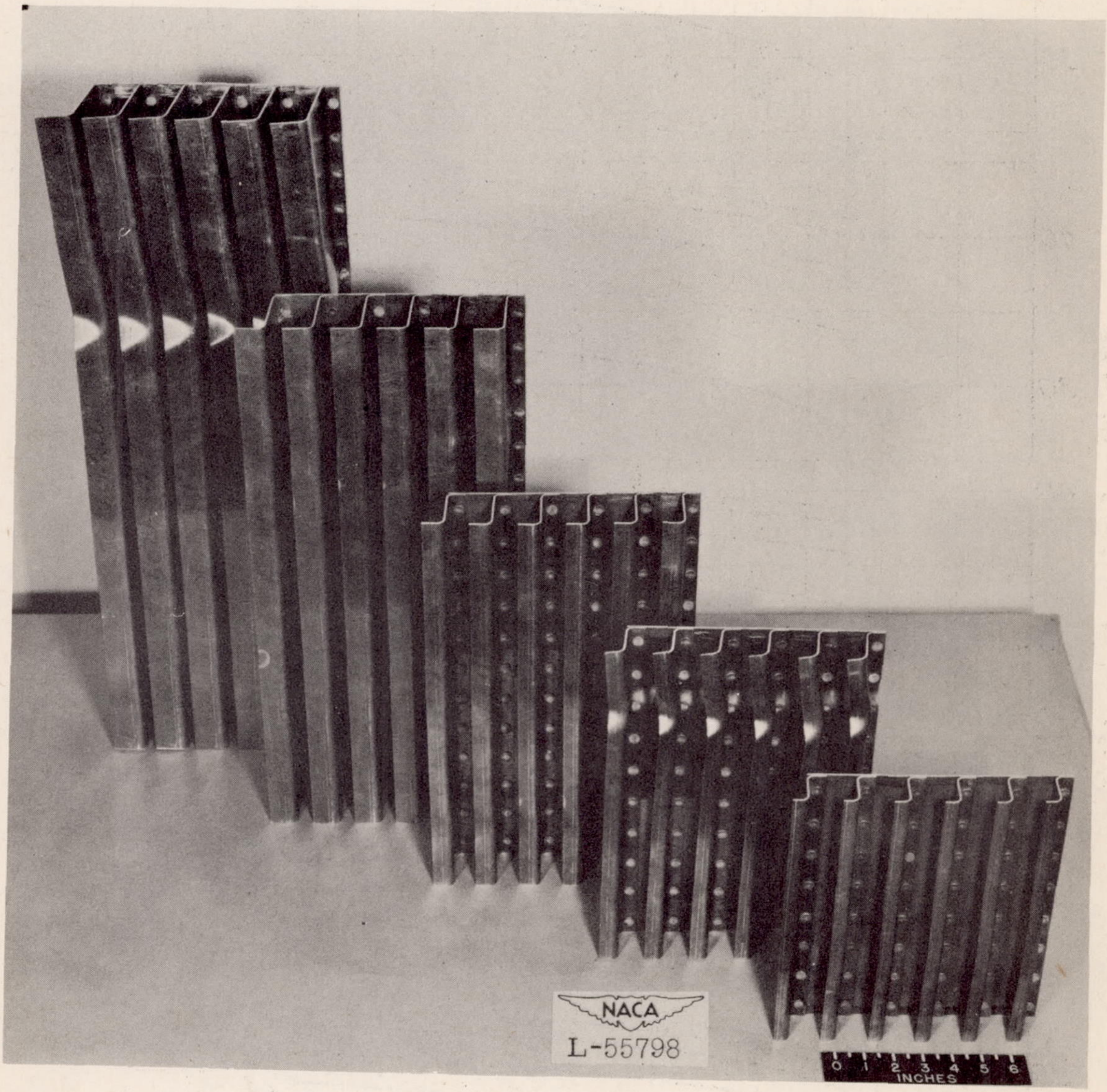
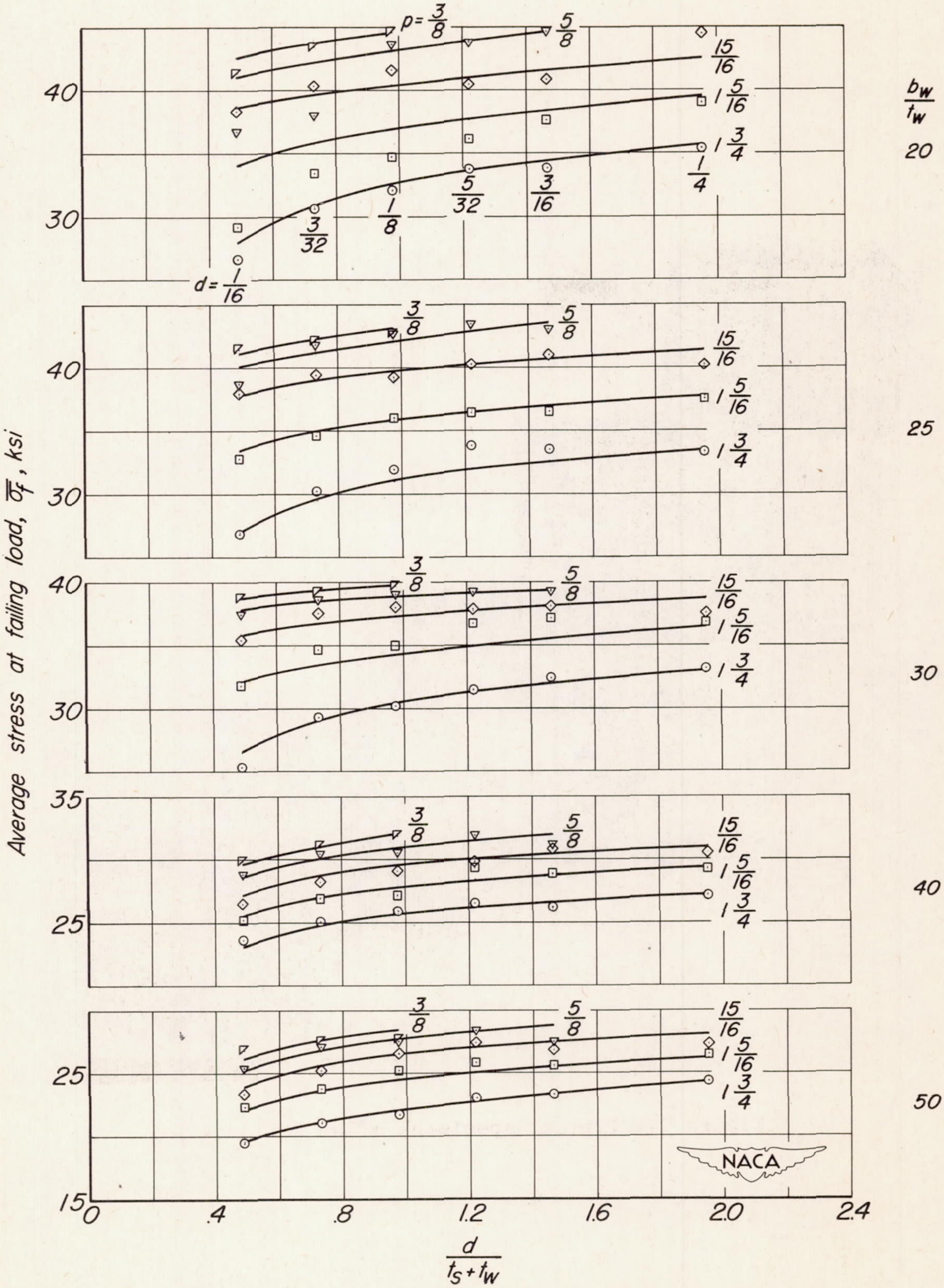
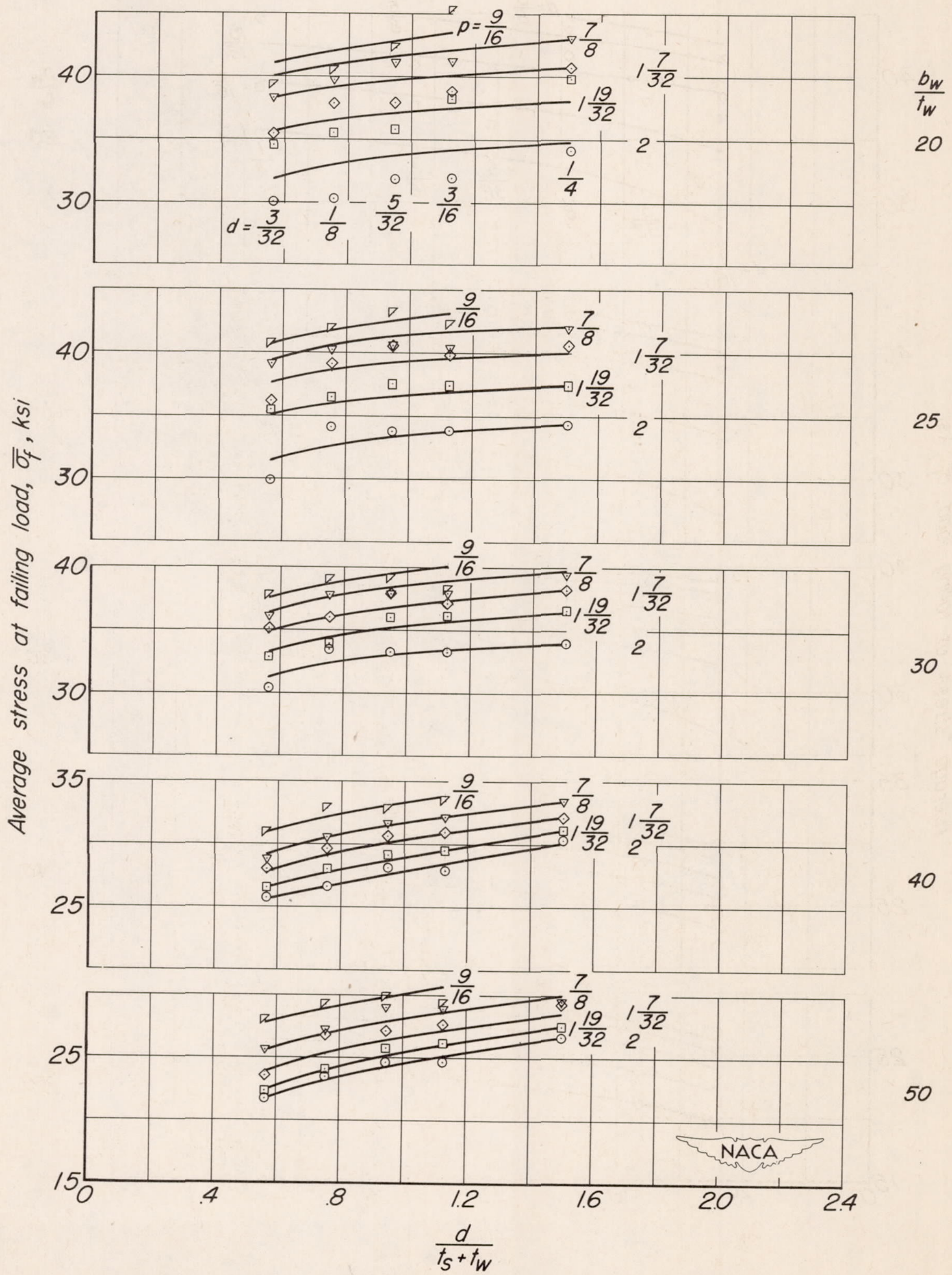


Figure 2.- Typical specimens after failure.



(a) $\frac{t_w}{t_s} = 1.00$; $t_s = 0.064$.

Figure 3.- Variation in compressive strength of panels with rivet diameter.



(b) $\frac{t_w}{t_s} = 0.63$; $t_s = 0.102$.

Figure 3.- Concluded.